Chapter 4 -- CONDITION OF THE GROUNDWATER RESOURCE

The Groundwater Coordinating Council (GCC) is directed by s. 15.347(13)(g), Wis. Stats., to submit an annual report which "…describes the state of the groundwater resource…" and to "…include a description of the current groundwater quality of the state…and a list and description of current and anticipated groundwater problems."

The purpose of this chapter is to describe the state [condition] of the groundwater resource, provide an assessment of groundwater quality and quantity issues, as well as describe current and anticipated groundwater problems. In general, groundwater is plentiful and of high quality in Wisconsin, but concern is growing about its limits and the existence of persistent and emerging threats. In addition, there is growing recognition of the interdependence of groundwater and surface water resources, as well as the influence of groundwater quantity on water quality. Further recommendations of the Council are listed in Chapter 6, *Future Directions for Groundwater Protection*.

GROUNDWATER QUALITY

As part of 1983 Wisconsin Act 410, the Groundwater Account of the Environmental Fund was created to support groundwater monitoring by state agencies to determine the extent of groundwater contamination in Wisconsin and identify the sources of contamination. Groundwater monitoring has found that the primary contaminants of concern are volatile organic compounds (VOCs), pesticides and nitrate. Increased attention is also being given to several "emerging threats," including naturally occurring radioactivity, arsenic, and microbial agents (bacteria, viruses, and parasites). Each is discussed below.

Volatile Organic Compounds

VOCs are a group of common industrial and household chemicals that evaporate, or volatilize, when exposed to air. Examples of VOCs include gasoline and industrial solvents, paints, paint thinners, drain cleaners, air fresheners, and household products (such as spot and stain removers). Short-term exposure to high concentrations of many VOCs can cause nausea, dizziness, tremors or other health problems. Some VOCs are suspected of causing cancer upon long-term exposure. Sources of VOCs in Wisconsin's groundwater include landfills, underground storage tanks (USTs), and hazardous substance spills.

Thousands of wells have been sampled for VOCs. Fifty-nine different VOCs have been found in Wisconsin groundwater, though only 34 of those have associated health standards. Trichloroethylene is the VOC found most often in Wisconsin's groundwater. **Figure 4.1** shows the location of drinking water wells with past ES and PAL exceedances based on data from 6,399 unique wells recorded in the GRN database.

Wisconsin has 72 active, licensed solid waste landfills, all of which are required to monitor groundwater. In addition, the DNR currently tracks about 20,000 leaking underground storage tanks (LUSTs) and about 4,000 waste disposal facilities. Many of these sites have been identified as sources of VOCs. Facilities include gas stations, bulk petroleum and pipeline facilities, plating, dry cleaning, industrial facilities, and abandoned non-approved unlicensed landfills.

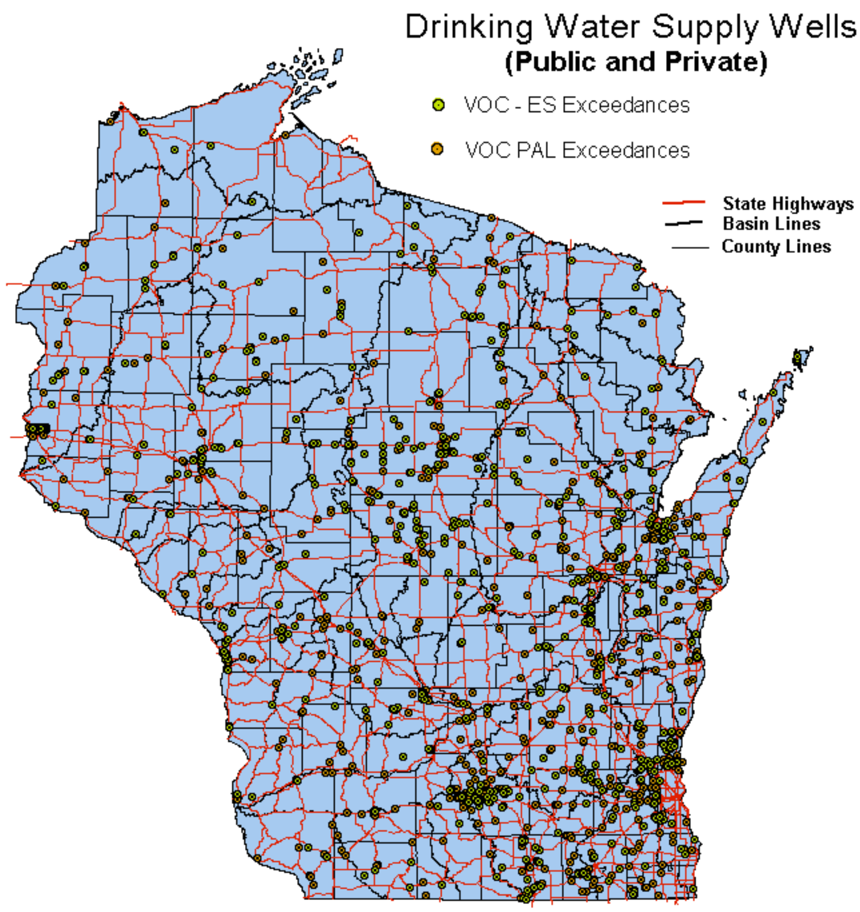

Figure 4.1 Volatile Organic Compounds (VOCs) past enforcement standard (ES) and preventive action limit (PAL) exceedances for public and private drinking water supply wells. Source DNR

Landfills. Two studies conducted over four years revealed that VOCs were significant contributors to groundwater contamination at Wisconsin landfills (DNR 1988, 1989). Out of a total of 45 unlined municipal and industrial landfills tested, 27 (60%) had VOC contamination in groundwater. All of these landfills are currently closed. Of 26 unlined municipal solid waste landfills tested, VOCs contaminated groundwater at 21 (81%). No VOCs were confirmed present at any of the six engineered (liner and leachate collection) landfills included in the studies. While 20 different VOCs were detected overall, 1,1 – Dichloroethane was the most commonly occurring VOC at all of the solid waste landfills.

In a follow-up VOC study conducted from July 1992 through July 1994, the DNR reviewed historical data and sampled groundwater at 11 closed, unlined landfills and at six lined landfills. VOC levels had decreased after closure at all but two of the unlined landfills, though at many sites VOC levels did not show continued improvement. Also, the level of contamination, while below initial concentrations, remained high at many closed sites. No VOC contamination attributable to leachate migration was found at any of the six lined landfills investigated.

Over the past few years increasing numbers of residential developments have been located close to old, closed landfills. In 1998 and 1999 the DHFS sampled private wells down-gradient of 17 small, closed landfills in Ozaukee County. Eight of the private wells had VOC results above maximum contaminant levels. The results of this sampling showed that there may be more landfills with serious problems that have not yet been identified.

The DNR Bureaus of Waste Management, Remediation and Redevelopment, and Drinking Water and Groundwater in cooperation with the DHFS, responded to this issue in early 1999 by evaluating 16 old, closed landfills – at least three from each of the five DNR regions across the state. Private wells around each of the landfills were sampled in 1999 and significant levels of contamination found. Of the 113 wells that were tested, 31 had detects of VOCs. Fourteen of the homes had levels exceeding drinking water standards and have been given health advisories not to drink their water.

Underground storage tanks. Wisconsin requires underground storage tanks with a capacity of 60 gallons or greater to be registered with the Department of Commerce. Since 1991, this registration program has identified over 175,000 underground storage tanks with over 80,000 federally regulated tanks with only about 12,500 tanks in use. A federally regulated tank is any tank, excluding exempt tanks, that is over 110 gallons in size, has at least 10 percent of its volume underground, and is used to store a regulated substance. Wisconsin regulates USTs down to 60 gallon capacity. Exempt tanks include: farm or residential tanks of 1,100 gallons or less; tanks storing heating oil for consumptive use on the premises where stored; septic tanks; and storage tanks situated on or above the floor of underground areas, such as basements and cellars.

Hazardous waste. Hazardous waste treatment storage and disposal facilities are another VOC source. The DNR Bureau for Remediation and Redevelopment is investigating or remediating contamination at about 30 sites. Approximately 140 sites statewide are subject to corrective action authorities. However, only a small percentage will follow the corrective action process because of minimal contamination at the site or jurisdiction under other regulatory authorities. Generators improperly managing hazardous waste are another source of VOC contamination. All new generator remediation cases statewide and many existing actions are to be addressed in accordance with the NR 700 Wis. Adm. Code series.

Hazardous Substance Spills. The Hazardous Substance Spill Law, ch. NR 292.11 Wis. Stats., requires immediate notification when hazardous substances are discharged, as well as taking actions necessary to restore the environment to the extent practicable. Approximately 800 discharges are reported annually to the DNR, and of those, approximately 65% are petroleum related, with another 15% being agrichemicals.

The NR 700 Wis. Adm. Code series, specifically ch. NR 706, contains the requirements for notification when a discharge or spill occurs. Chapter NR 708 contains requirements for taking immediate and/or interim actions when releases occur. Groundwater monitoring is performed when necessary to delineate the extent of contamination. The spills program develops outreach materials to help reduce the number and magnitude of spills and provide guidance for responding to spills. Topics addressed include spills from home fuel oil tanks, responses to illegal methamphetamine labs, and mercury spills, all of which can lead to significant environmental impacts, if not properly addressed.

References cited:

DNR, 1988. Volatile Organic Compounds in Groundwater and Leachate at Wisconsin Landfills. Wisconsin Department of Natural Resources, Bureau of Solid and Hazardous Waste, February 1988.

DNR, 1989. VOC Contamination at Selected Landfills – Sampling Results and Policy Implications. Wisconsin Department of Natural Resources, Bureau of Solid and Hazardous Waste, June 1989.

Pesticides

Pesticide contamination in groundwater results from field applications, pesticide spills, misuse, or improper storage and disposal. Serious concerns about pesticide contamination in Wisconsin were first raised in 1980 when aldicarb, a pesticide used on potatoes, was detected in groundwater near Stevens Point. The DNR, DATCP, and other agencies responded to these concerns by implementing monitoring programs and conducting groundwater surveys.

The DNR and DATCP expanded their sampling programs in 1983 to include analysis of pesticides commonly used in Wisconsin. The most commonly detected pesticides in Wisconsin groundwater are:

- Metabolites of alachlor (Lasso), metolachlor (Dual) and acetochlor (Harness)
- Atrazine and its metabolites
- Metribuzin (Sencor)
- A metabolite of Cyanazine (Bladex). Cyanazine is no longer manufactured.

Federal and state groundwater quality standards for many of these compounds have also been adopted. To date, standards for over 30 pesticides are included in ch. NR 140, Wis. Adm. Code.

<u>Atrazine</u>, a herbicide used on corn, is one of the pesticides most often found in private drinking water wells in Wisconsin. There are significant health concerns for humans and wildlife associated with atrazine. Recent studies have found that male frogs develop both male and female sex organs when exposed to concentrations of atrazine at 1/30th of the current drinking water standard (Hayes et. al. 2002 and Hayes et. Al. 2003)

The first systematic well sampling program to characterize atrazine contamination on a statewide basis was the 1988 DATCP Grade A Dairy Farm Well Water Quality Survey. This state-funded well survey estimated that atrazine was present in 12% of the Grade A Dairy Farm Wells in the State. Since that initial study, DATCP has collected data from many private and monitoring wells in the state as part of statewide surveys and focused monitoring projects (summarized below).

In July 2005, DATCP produced a map showing locations of private drinking water wells tested for atrazine in the state (**Figure 4.2**). The DATCP pesticide database contains test results from nearly 16,000 wells tested with the immunoassay screen for atrazine and over 7000 wells tested by the full gas chromatograph method. The immunoassay screen results show that about 40% of private wells tested have atrazine detections, while about 1% of wells contain atrazine over the groundwater enforcement standard of 3 µg/L. The 7000 wells tested by full gas chromatograph show detectable levels of atrazine 25% of the time and are over the enforcement standard in about 5% of the wells. The enforcement standard for atrazine includes parent atrazine and three of its breakdown products (metabolites).

Some pesticides, like atrazine, get into groundwater mostly through general use, while others are only found in groundwater if they have been spilled or mishandled. A combination of factors is most likely responsible for the widespread atrazine contamination shown on this map:

- Atrazine has been the most widely used herbicide in Wisconsin for more than 30 years because it is effective and inexpensive

- Atrazine was commonly used at much higher rates and applied more often before DATCP's Atrazine rule (ch. ATCP30, Wis. Adm. Code) began in 1991
- Atrazine sinks (leaches) through the soil into groundwater faster than many other herbicides

<u>Triazine screen</u>. In 1991, the Wisconsin State Laboratory of Hygiene (WSLH) began a public testing program using an immunoassay screening test for triazine-based compounds, such as atrazine. The triazine immunoassay screen uses specific antibodies designed to selectively bind to target compounds that are present at low concentrations. While there is no enforcement standard (ES) for the triazine screen, comparing the triazine results to the ES and preventive action limit (PAL) for atrazine provides a reference point for the severity of contamination. In a recent survey of DNR groundwater databases, more than 14,000 triazine screen results have been recorded. Forty-two percent of the samples had a detection for a triazine compound; 13% exceeded the PAL for atrazine of 0.3 µg/L; and 1.6% exceeded the ES for atrazine of 3.0 µg/L.

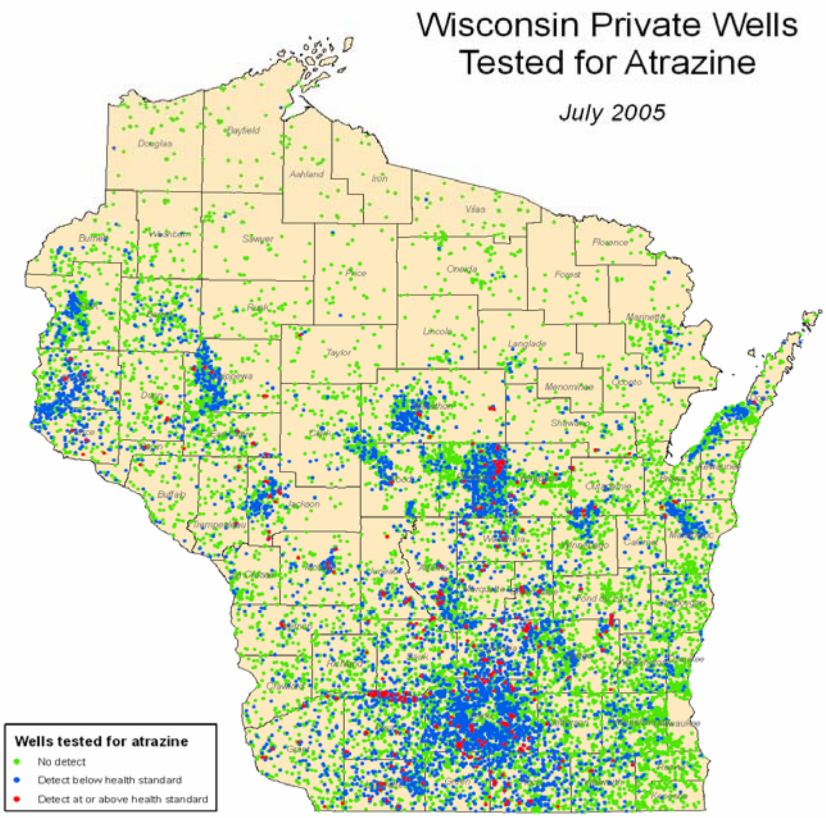

Figure 4.2 Private wells tested for atrazine in Wisconsin as of July 2005. Source: DATCP

One problem with the triazine screen is that it does not detect all the atrazine metabolites and therefore underestimates the total atrazine concentration. The WSLH advises homeowners that the triazine screen results should be used for initial screening purposes only. Higher triazine detects often receive a follow-up gas chromatography test. In 2002, the DNR funded a study with the WSLH to evaluate a new immunoassay test for the metabolite diamino atrazine. Results were delivered in late 2003 and it appears that a combination of new and existing tests can improve analytical accuracy greatly.

Chloroacetanilide herbicide metabolites are increasingly being detected in Wisconsin groundwater. In a study completed in 2000, 27 monitoring wells, 22 private drinking water wells, and 23 municipal wells in Wisconsin were sampled for alachlor, metolachlor, acetochlor, and their ethane sulfonic acid (ESA) and oxanillic acid (OA) metabolites. Wells were selected based on previous detections of pesticides or proximity to agricultural fields. Alachlor, metolachlor, and acetochlor are chloroacetanilide herbicides that are commonly used on corn and other crops in Wisconsin. With the exception of alachlor ESA, no historical data exists for these metabolites in Wisconsin groundwater because laboratory methods were not previously available. Over 80 percent of the monitoring wells and drinking water wells included in the survey contained the ESA and OA metabolites of alachlor and metolachlor. The metabolites of acetochlor showed a lower frequency of detection. Metabolite concentrations ranged from near the level of detection to 42 µg/L. Monitoring wells and private drinking water wells showed higher detection frequencies and concentrations than the deeper municipal wells, but the municipal wells did show significant impacts. Fifty-two percent of the municipal wells had at least one detection. No municipal well had pesticide levels that exceeded an enforcement standard.

Beginning in October 2000 and ending in May 2001, DATCP collected 336 samples from private drinking water supplies to determine the statewide impact of pesticides on groundwater resources (DATCP 2002). DATCP analyzed the samples for commonly used herbicides including the chloroacetanilide herbicides and their metabolites. This study also was compared to previous surveys to attempt to understand trends in groundwater quality over time. A total of seven common herbicides, ten metabolites and nitrate were included in the latest survey. Highlights from this overall study show:

- The proportion of wells that contain a detectable level of a herbicide or herbicide metabolite is 37.7%.
- Alachlor ESA and metolachlor ESA are the most commonly detected herbicide compounds with proportion estimates of 27.8 and 25.2%, respectively.
- A statistically significant decline in parent atrazine concentrations between 1994 and 2001.
- However, a decline in total chlorinated residues of atrazine was not apparent.

The following are other DATCP pesticide related studies conducted recently or as part of ongoing research.

Exceedance Survey. In 1995, DATCP completed a re-sampling of 122 Wisconsin wells that previously exceeded a pesticide enforcement standard. Most of the wells in the survey had exceeded standards for atrazine. Most were also within an atrazine prohibition area. Of wells exceeding standards for atrazine, 84% had declined in concentration and 16% had increased. About 50% of well owners continued to use their contaminated well and about 25% had installed new wells at an average cost of $6,300. This well survey has been repeated annually through 2005, with samples collected from 150 different wells at least once during this time period. As of 2005, atrazine levels have gone down in 82% of the wells, up in 15%, and stayed about the same in 3%. Eighteen wells remain above the enforcement standard.

Pesticide and Groundwater Impacts Study. In 1985, DATCP began a 2-year study funded by the Wisconsin DNR to evaluate the potential impact of agriculture on groundwater quality. The study focused on areas of the state with high groundwater contamination potential. In 2005, this study entered its 20th program year. In 2005 samples from monitoring wells near 15 agricultural fields were sampled. A total of ten compounds were detected in groundwater. Three of these (nitrate, alachlor ESA and atrazine + metabolites) were found at levels above an existing water quality standard. Other compounds detected include alachlor, acetochlor ESA, metribuzin, metolachlor and its ESA and OA metabolites, and cyanazine amide.

Monitoring Reuse of Atrazine in Prohibition Areas - In FY 98 through FY 05, DATCP monitored the limited reuse of the herbicide atrazine in selected areas where atrazine use has been prohibited. DATCP gathered the data to see if renewed atrazine use at current restricted use rates will cause groundwater contamination. DATCP monitored groundwater quarterly at 17 fields, 10-40 acres in size, for 5 to 7 years. Although a final determination of the project's findings has not yet been made 1998 through 2005 summary data showed that all of the sites that followed study protocols exceeded the ES for atrazine at some point during the study. The nitrate enforcement standard was exceeded at 100% of these sites over the same sampling period.

References cited:

DATCP, 2002. Groundwater Quality: Agricultural Chemicals in Wisconsin Groundwater. Wisconsin Department of Agriculture, Trade and Consumer Protection, Water Quality Section, ARMPUB98.qxd. 18 p. Copies of this survey, as well as summaries of other DATCP monitoring projects are available at *http://datcp.state.wi.us/arm/agriculture/land-water/water-quality/monit_proj.html*.

Hayes, T; K, Hason; M. Tsui; A, Hoang; C. Haeffele; and A. Vonk. 2002 Feminization of male frogs in the wild. *Nature*, 419:895-896.

Hayes, T; K, Hason; M. Tsui; A, Hoang; C. Haeffele; and A. Vonk. 2003 Atrazine-Induced Hermaphroditism at 0.1 PPB in American Leopard Frogs (*Rana pipiens*): Laboratory and Field Evidence. *Environmental Health Perspectives* 111:111:568-575.

Nitrate

Two Wisconsin state agencies, the DNR and DATCP, both agree that nitrate is the most widespread groundwater contaminant in Wisconsin and is increasing in extent and severity. Nitrate (NO3-N) is a water-soluble molecule made up of nitrogen and oxygen that forms when ammonia or other nitrogen rich sources combine with oxygenated water. Nitrate occurs naturally in water but only at very low levels of less than 1 milligram per liter (mg/L), higher levels indicate a source of contamination. Common sources of nitrate contamination include fertilizers, animal wastes, septic tanks, municipal sewage treatment systems, and decaying plant debris.

Since 80% of nitrate inputs into groundwater originate from manure spreading, agricultural fertilizers, and legume cropping systems (Shaw, 1994), it makes sense that nitrate contaminated wells are found to be more prevalent in agricultural districts. Studies have repeatedly shown that predominantly agricultural counties in southern and west-central parts of Wisconsin have a higher percentage of wells exceeding the 10 mg/L federal and state nitrate enforcement standard (ES).

In a 1994 study, WGNHS and DHFS estimated that 9 to 14% of private water wells in Wisconsin exceed the nitrate standard. A 1997 DATCP study showed exceedance rates of 17 to 26% for wells in agricultural districts. In 2005, DNR aggregated and analyzed data from three extensive statewide groundwater databases as part of a "Condition of the Resource" paper focused on the contamination of nitrate in Wisconsin groundwater. This combined dataset from DNR's Groundwater Retrieval Network (GRN) database (25,894 samples), the Center for Watershed Science and Education database (21,525 samples) and DATCP's groundwater database (1,399 samples), includes only the most recent nitrate result for each sampled private well. Out of the 48,818 samples, 5686 (11.6 %) equaled or exceeded the ES of 10 mg/L. As seen in **Figure 4.3**, the percent of wells exceeding the ES varies across the state. Calumet, Columbia, Dane, La

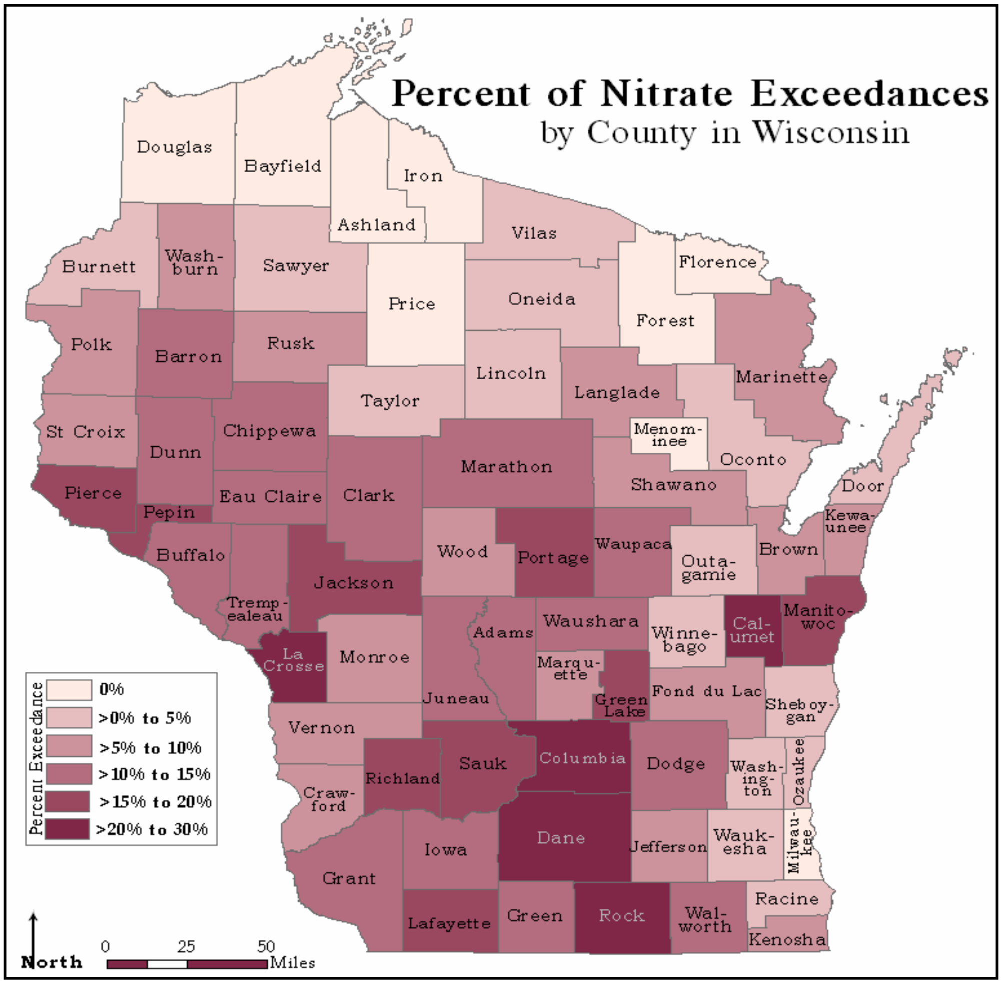

Figure 4.3 - Percentage of nitrate samples from private wells exceeding 10mg/L by county. Date sources: DNR, Center for Watershed Science and Education, and DATCP groundwater databases.

Crosse and Rock counties all show the highest percent exceedances with 20% to 30% of the samples from private wells exceeding the 10 mg/L ES.

Human health concerns are the primary reason high levels of nitrate in drinking water are of concern. Nitrate can cause a condition called methemoglobenemia or "blue-baby syndrome" in infants under six months of age. Nitrate in drinking water used to make baby formula is converted to nitrite in the child's stomach, the nitrite then changes hemoglobin in blood (that part of the blood that carries oxygen to the body) to methemoglobin which deprives the infant of oxygen and in extreme cases can cause death. The Wisconsin DHFS has investigated several cases of suspected blue-baby syndrome and associated at least two with nitrate contaminated drinking water. These two non-fatal cases were reported in Columbia County (July 1998) and Grant County (April 1999). The Grant County case required an emergency MedFlight to a regional medical center and 17 day hospitalization to stabilize the 3 week old infant (Knobeloch, 2000).

When nitrate converts to nitrite in the human body it can then convert into a carcinogen called N-nitroso compounds (NOC's). NOC's are some of the strongest know carcinogens and have been found to induce cancer in a variety of organs. As a result, additional human health concerns linked to nitrate contaminated drinking water include; increased risk of: non-Hodgkin's lymphoma (Ward et al., 1996); gastric cancer (Xu et al., 1992; Yang et al., 1998); and bladder and ovarian cancer in older women (Weyer et al., 2001). There is also growing evidence of a correlation between nitrate and diabetes in children (Parslow et al., 1997; Moltchanova et al., 2004).

Because of these health concerns, city and village water supplies that exceed the 10 mg/L ES are required to mitigate the problem. Common solutions include drilling of a new non-contaminated well or the removal of excess nitrate through water treatment processes. Currently 25 (up from just 14 in 1999) of Wisconsin's public drinking water systems have exceeded the nitrate ES and have collectively spent over $24 million on remedies.

The 10 mg/L ES is also advised for privately owned wells that supply drinking water; however, the individual owners carry the responsibility of making sure their wells are tested. Private wells should be tested for nitrate at the time of installation and at least every five years during their use. Testing is also recommended for wells used by pregnant women and is essential for wells that serve infants less than 6 months of age. Owners of nitrate-contaminated water supplies have few mitigation options. They do not qualify for well-compensation funding unless the nitrate level in their well exceeds 40 mg/L and is used for farm stock. In order to establish a safe water supply, they may opt to replace an existing well with a deeper, better cased well or to connect to a nearby public water supply. Alternatively, they may choose to install a water treatment system or to use bottled water. A study published by DHFS examined this issue (Schubert et al., 1999). Their survey of 1500 families found that few took any action to reduce nitrate exposure. Of those who did, most purchased bottled water for use by an infant or pregnant woman.

With nitrate contamination increasing in extent and severity, it makes sense to reduce the amount of nitrate inputs into Wisconsin groundwater. Current proposed changes to state rules that could decrease groundwater nitrate contamination (at least near existing wells) include:

<u>NR243</u> – Would lower the levels of nitrogen associated with manure and process wastewater from reaching groundwater by reducing improperly designed manure storage facilities and excessive or improper application of manure and process wastewater on cropped fields. This proposed rule applies to large Concentrated Animal Feeding Operations, 1000 animal units and larger. There are about 150 of these permitted operations currently.

<u>ATCP51</u> – With its emphasis on water quality protection, this new livestock siting standard would afford protection to areas susceptible to groundwater pollution. Required standards would prevent runoff from entering sinkholes, ensure that existing storage structures do not leak, and require application of manure according to plan that minimizes risks to groundwater. It would impose standards that will reduce water pollution risks including the potential for well contamination. This adopted rule applies

to new and expanding farms, typically over 500 animal units and would apply to about 70 farms annually.

ATCP50 – This rule applies to all farms and includes the requirement of all farms in Wisconsin to implement nutrient management plans by 2008. Similar to NR243 and ATCP51 it would require farms to use UW recommendations for nutrients including nitrogen. As mentioned in the introduction, current over-application of nitrogen sources to farm fields likely accounts for most of the nitrate loading to groundwater in the state. Application to UW recommendations will reduce nitrate loading and improve groundwater quality.

References cited:

Knobeloch L, Salna B, Hogan A, Postle J, Anderson H. 2000. Blue babies and nitrate contaminated well water. Environ Health Perspectives 108(7): pgs.675-678.

Moltchanova E, Rytkonen M, Kousa A, Taskinen O, Tuomilehto J, Karvonen M. 2004. Zinc and nitrate in the ground water and the incidence of Type 1 diabetes in Finland. Diabetic Medicine 21: pgs.256-261.

Parslow RC, McKinney PA, Law GR, Staines A, Williams R, Bodansky HJ. 1997. Incidence of childhood diabetes mellitus in Yorkshire, northern England, is associated with nitrate in drinking water: an ecological analysis. Diabetologia 40(5): pgs.550-556.

Schubert C, Knobeloch L, Kanarek MS, Anderson HA. 1999. Public response to elevated nitrate in drinking water wells in Wisconsin. Arch Environ Health 54(4): pgs.242-247.

Shaw B, 1994. Nitrogen Contamination Sources: A Look at Relative Contributions in Conference Proceedings – Nitrate in Wisconsin’s Groundwater: Strategies and Challenges: p.23.

Ward MH, Mark SD, Cantor KP, Weisenburger DD, Correa-Villasenor A, and Zahm SH. 1996. Drinking water nitrate and the risk of non-Hodgkin's lymphoma. Epidemiol 7(5): pgs.465-471.

Weyer PJ, Cerhan JR, Kross BC, Hallberb GR, Kantamneni J, Breuer G, Jones MP, Zheng W, Lynch CF. 2001. Municipal drinking water nitrate level and cancer risk in older women: The Iowa Women’s Health Study. Epidemiology 11(3): pgs.327-338.

Xu G, Song P, Reed PI. 1992. The relationship between gastric mucosal changes and nitrate intake via drinking water in a high-risk population for gastric cancer in Moping county, China. Eur J Cancer Prev 1(6): pgs.437-443.

Yang CY, Cheng MF, Tsai SS, Hsieh YL. 1998. Calcium, magnesium, and nitrate in drinking water and gastric cancer mortality. Jpn J Cancer Res 89(2): pgs.124-130.

Microbial agents

The United States produces some of the cleanest drinking water in the world and yet there are still reports of waterborne disease outbreaks. These outbreaks are produced by microbial agents including bacteria, viruses and parasites. These agents can cause acute and chronic illnesses and result in life-threatening conditions for individuals with weakened immune systems. Of the approximately 20 outbreaks reported nationally per year, more than half are related to groundwater consumption (Lee, et al. 2002). Many waterborne outbreaks are not reported or detected.

In one statewide assessment a decade ago, approximately 23% of private well water samples statewide tested positive for total coliform bacteria, an indicator species of other biological agents (Warzecha et al 1995). Approximately 3% of private well water samples tested positive for *E. coli*, an indicator of water borne disease that originates in the mammalian intestinal tract.

Some parts of the state are particularly vulnerable to microbial contamination. Microbiological contamination often occurs in areas where the depth to groundwater or depth of soil cover is shallow or in areas of fractured bedrock. In these areas, there is little natural attenuation potential. Door County is one such location where bedrock is fractured and wells are often shallow.

In a recent survey of 25 private wells in Door County, 18 had detections of total coliform in at least one monthly sample over a 1-year period (Braatz, 2004). 40% had detections of a fecal indicator (*E. coli* or enterococci). Significant seasonal trends were also apparent, with higher percentages of wells with fecal indicators in the summer months. There was also a waterborne illness outbreak at a Door County restaurant in December 2004 (Wisconsin DNR).

Researchers at the Marshfield Clinic Research Foundation have investigated the association of pathogenic viruses and bacteria in private wells with incidences of infectious diarrhea and indicators of well water contamination (Borchardt et al. 2003b). In general, infectious diarrhea was not associated with drinking from private wells, nor was it associated with drinking from wells positive for total coliform. However, wells positive for enterococci were associated with children having diarrhea of unknown etiology, which was likely caused by Norwalk-like viruses. Results from a subsequent study of 50 private wells throughout the state indicate that 8% of private wells may be subject to virus contamination (Borchardt et al. 2003a). Wells positive for viruses were not consistent seasonally, nor were they associated with commonly used indicators of microbial contamination such as total coliform or fecal enterococci. These studies suggest that increased monitoring and detection methods for viruses are needed to assess the risk of drinking water with potential microbial contamination.

In another recently completed study in collaboration with the US Geological Survey, Marshfield researchers found that 50% of water samples collected from four La Crosse municipal wells were positive for enteric viruses, including enteroviruses, rotavirus, hepatitis A virus, and Norwalk-like virus (Borchardt et al. 2004). As with the private well study, there was no correspondence to common indicators of sanitary quality, nor was there a consistent seasonal trend. More surprising, viruses were common even in those wells without any Mississippi River water infiltration, suggesting other fecal sources were contaminating the wells. The most likely source is leaking sanitary sewers. The study did not address whether the viruses are inactivated through disinfection processes, or result in illness in the community.

The DNR recommends that private well owners test for microbial water quality annually or when there is a change in taste, color, or odor of the water. Public drinking water systems that disinfect their water supplies are required to sample, on a quarterly basis, for bacteria from the raw water (before treatment) in each well. These raw water samples are representative of the source from which the wells draw groundwater. The DNR has recently begun tracking total coliform detects in the raw water samples through its Drinking Water System database. The number of public water systems and locations where groundwater samples are collected quarterly for microbial analysis, along with the number of total coliform positive (TCP) samples for the period July 1, 2004 through June 30, 2005 are listed in the following table.

System type	# systems w/ Raw Req.	# locations w/ Raw Req.	# Raw TCP samples	# sys w/ Raw TCP
Municipal (MC)	475	1350	204	60 (12.6%)
Other-than-municipal (OTM)	64	100	9	6 (9.4%)
Non-transient, non-community (NN)	38	59	6	3 (7.9%)
Transient non-community (TN)	39	40	9	5 (12.8%)

Most wells belonging to the group of transient non-community systems (TN), such as restaurants and convenience stores, sample for bacteria on an annual basis. These systems have very small distribution systems and are similar to private water systems in that their water samples represent the groundwater source. There are approximately 9500 active TN systems in Wisconsin.

Data from the Environmental Protection Agency (EPA) shows that the highest percentage of microbial unsafe water is found in small water systems, like TNs, serving less than 500 people (Peterson 2001). The mobility of transient people consuming water at small water systems and general lack of knowledge of illness symptoms hinder waterborne illness outbreak identification.

Nationally, the Center for Disease Control continues to track and identify failures in water systems that lead to illness outbreaks. Because of the increasing evidence for widespread occurrence of microbial contaminants, additional monitoring requirements for vulnerable public water systems are on the horizon. The Environmental Protection Agency (EPA) is developing a strategy, known as the "Groundwater Rule," which would modify Safe Drinking Water Act requirements to increase detection of fecal contamination in groundwater and reduce the occurrence of illness from microbial pathogens. The Groundwater Rule will include 5 preventative strategies that prior EPA drinking water legislation did not adequately address.

The first strategy includes sanitary surveys of public systems to identify deficiencies. The second strategy is a hydrogeologic sensitivity assessment of each public system to identify wells sensitive to fecal contamination. The third strategy is source water monitoring. Currently, the Safe Drinking Water Act focuses on sampling for microbial indicators in the distribution system. Fourth, the law will require corrective action for non-complying features found in the water system and eliminating fecal contamination with treatment or providing an alternative permanent source of water. The fifth strategy of the law is monitoring requirements to ensure that treatment equipment is maintained.

Wisconsin already conducts inspections and requires correction of non-complying features. Therefore, the major changes resulting from the proposed EPA law will be additional monitoring of source water for sensitive systems and installation of approved treatment devices or a new water source the wells found to contain fecal contamination.

References cited:

Borchardt, M. A., P. D. Bertz, S. K. Spencer, and D. A. Battigelli. 2003a. Incidence of enteric viruses in groundwater from household wells in Wisconsin. Applied and Environmental Microbiology, 2003, Vol 69, Iss 2, pp 1172-1180.

Borchardt, M. A., P. H. Chyou, E. O. DeVries, E. A. Belongia. 2003b. Septic system density and infectious diarrhea in a defined population of children. Environmental Health Perspectives, 2003, Vol 111, Iss 5, pp 742-748

Borchardt MA, Haas NL, Hunt RJ. 2004. Vulnerability of municipal wells in La Crosse, Wisconsin, to enteric virus contamination from surface water contributions. *Applied and Environmental Microbiology* Vol 70: 5937-5946.

Braatz, L., 2004. A study of fecal indicators and other factors impacting water quality in private wells in Door County, Wisconsin. Master of Science thesis submitted to Univeristy of Wisconsin-Green Bay, December 2004. 124 p.

Hunt, R., and M. Borchardt. 2003. Susceptibility of La Crosse municipal wells to enteric virus contamination from surface water contributions. Final report submitted to Wisconsin Department of Natural Resources, June 23, 2003.

Lee SH, Levy DA, Craun GF, Beach MJ, Calderon RL. 2002, Surveillance for waterborne-disease outbreaks--United States, 1999-2000. MMWR Surveill Summ 2002;51:1-47.

Peterson, H. G., 2001. Rural Drinking Water and Waterborne Illness. Safe Drinking Water Foundation, Saskatoon, SK, p. 162-191.

Warzecha, C., R. Gerhardt, and S. Kluender. 1995. Wisconsin private well water quality survey. Wisconsin Department of Health and Social Services, Department of Natural Resources, and State Laboratory of Hygiene. Unpublished report.

Wisconsin DNR, 2004. Unpublished Door County Files, Sturgeon Bay office.

Arsenic

The DNR became aware of naturally occurring arsenic in groundwater and water supply wells in the early 1990's. Initial investigations found that in NE Wisconsin about 3.5% of wells tested were greater than the then current standard of 50 µg/L. The highest well tested at 15,000 µg/L. The DNR issued an advisory for the area which recommended drilling and casing 80 feet beyond the top of the St Peter sandstone where the main arsenic bearing zone was determined to be. This proved to be over 85% successful in bringing arsenic concentrations to below 50 µg/L. Over the years the department has continued to work with drillers to improve construction techniques to minimize arsenic in potable wells.

Arsenic is released from aquifer materials by several mechanisms. The primary mechanism in NE Wisconsin is oxidative breakdown of sulfide minerals. This is caused both by well construction techniques and by local and regional drawdown caused by increasing water use. When this happens, other metals which are also in the sulfides are also released, often times in concentrations that may pose health risks. These metals include nickel, cobalt, cadmium, chromium, lead and iron. A different release mechanism is predominant in SE Wisconsin and along glacial moraines in Northern Wisconsin. In these areas arsenic is bound to iron oxides in the aquifer material and is released due to reduction reactions. When iron oxide is reduced the arsenic is freed into groundwater.

With a new federal standard on the horizon the department coordinated with DHFS and local health departments to sample private wells in several towns in Outagamie and Winnebago

Counties. Over 3900 wells were sampled between 2000 and 2002. Results were delivered to the homeowners at public information meetings. Results indicated that overall about 20% of the wells had concentrations over the new standard of 10 µg/L (the same as the earlier sampling). In some areas, over 40% of the wells exceeded 10 µg/L. One key area was the high density development in the Town of Algoma - just west of Oshkosh. The department made this the first special well casing depth area (SWCDA) in 2002. Three other smaller areas followed soon after.

Between 2002 and 2004 the DNR required more stringent specifications within four small areas where arsenic contamination problems were severe. But it was realized that if SWCDAs were established in this manner, it would result in a 'hodge-podge' of small areas, scattered over a two-county region. So it was decided to seek a more comprehensive regional approach.

The goal was to produce maps delineating low arsenic zones and provide well drillers with guidelines for constructing wells in those aquifers. DNR and WGNHS staff used approximately 14000 wells over a 12 county area to provide a regional context. In the problem area in Outagamie and Winnebago counties over 6000 well constructor reports (WCR) were interpreted to contour problem areas between the top of the St Peter sandstone and top of the Cambrian formations. Maps were then produced giving the maximum depth of a shallow well option or the minimum depth of casing to reach the Cambrian sandstone aquifer. Information on the specifics of the requirements can be found at: *http://dnr.wi.gov/org/water/dwg/arsenic/index.htm* under special casing areas.

Based on the success of the SWCDA and the high levels of wells the DNR moved forward with expanding the SWCDAs to cover the entire counties. Working with the WGNHS and well drillers from the area, detailed maps of casing depths were generated. (See more under interagency coordination) The maps and construction requirements can be seen at: *http://dnr.wi.gov/org/water/dwg/arsenic/casingrequire.htm*

The project has been a good example of interagency cooperation. Initial work with DHFS and local health departments and town boards effectively define the problem and raised awareness. . Research supported by the joint solicitation helped define the extent and mechanisms of release. DNR and Commerce worked jointly with water treatment companies on developing treatment systems for arsenic removal. Well drillers assisted in identifying drilling methods that reduce arsenic.

Since the realization of the problem in the early 1990's much research has been focused on the arsenic problems. Sixteen studies through the joint solicitation have explored arsenic related topics from detection to geologic controls to well construction and treatment. (See appendix C and "Arsenic Monitoring and Research in Northeastern Wisconsin" in chapter 5). Arsenic concentrations greater than 10 µg/L have been documented in 51 counties. The studies have helped develop real working solutions in the SWCDA. Much has been learned from these studies but much remains to be learned.

Current research is focused on release mechanisms, triggers and reaction kinetics that effect well finishing and rehabilitation operations. The other focus is defining the problem in other areas of the state. For example recently 4 wells in Pierce County had arsenic ranging from 5-59 µg/L. Other metals were also elevated. Lead was as high as 927 µg/L, zinc to 21,000 and nickel and manganese were over 1700 µg/L. With the assistance of WGNHS staff who were mapping the area, a new well was drilled, logged with geophysical equipment and tested. The logging will help with understanding the structure and distribution of arsenic bearing minerals in that part of the state. Already what was learned there has helped with the design of a new municipal well for Turtle Lake.

The DNR, DHFS, Commerce and others continue to work on the arsenic problems around the state. Arsenic has been found in groundwater in every county in the state. DHFS has shown health outcome effects in two separate studies. In addition there are 2 known cases of confirmed arsenic poisoning from drinking water. (In both cases neurological damage was moderate to severe.) Current arsenic work includes:

- Refinement of the geology in the Outagamie and Winnebago county area and updating casing requirements,
- DHFS and DNR sampling of transient non community wells
- DHFS and DNR targeting of wells for sampling in the southern and SW potions of the state
- Commerce and DNR evaluating and pilot testing arsenic treatment systems for public and private systems that do not have an alternative aquifer option.
- DNR and local governments are working with several Blue Cross / Blue Shield grants for a healthier Wisconsin to explore impediments to private wells sampling and promote well sampling programs
- DNR efforts to improve well construction for schools and community wells
- DHFS, DNR and the WGNHS are working together to gather information from drillers and pump installers on areas with high iron and corrosive water, which may be indications of an arsenic problem. Sampling of these areas is being lead by DHFS.
- A new study funded through the joint solicitation will begin in July 2006 involving researchers from Wisconsin and West Virginia. WGNHS and the DNR are working to add new data to the geologic model for the SWCDA and refine the mapping project.
- Educational outreach to the well drillers continues.

More information related to arsenic can be found on the DNR Arsenic Web Page:
http://dnr.wi.gov/org/water/dwg/arsenic/index.htm

Naturally-Occurring Radionuclides

Naturally-occurring radionuclides, including uranium, radium, and radon are becoming an increasing concern for groundwater quality, particularly in the Cambro-Ordovician aquifer system in eastern Wisconsin. The water produced from this aquifer often contains combined radium activities in excess of 5 pCi/L (picocuries/liter) and in some cases in excess of 30 pCi/L. Nearly 60 public water systems exceed the drinking water standard of 15 pCi/L for gross alpha activity (**Figure 4.4**). The DNR is enforcing the radionuclide standard adopted into NR 809. The DNR has signed consent orders with 42 community water systems that will bring them into compliance with drinking water standards for radium and gross alpha by December of 2006.

Previous studies have shown that radium concentrations in excess of 5 pCi/L can not be explained solely by the presence of parent isotopes in the aquifer solids. It is possible that high radium concentrations in Cambro-Ordovician water originate from downward flow of recharge water through the Maquoketa Shale. Indeed, high radium activity occurs in the Cambro-Ordovician in a band roughly coincident with the Maquoketa subcrop pattern (Grundl, 2001). This pattern extends across the entire eastern portion of the state from Brown County in the north to Racine County in the south. Radium activities have remained relatively constant from the middle 1970s to the present. High gross alpha activity also occurs in a band roughly coincident with the Maquoketa subcrop pattern extending along the entire eastern portion of the state.

The Maquoketa outcrop pattern forms the demarcation between unconfined conditions in the underlying Cambro-Ordovician aquifer to the west and confined conditions to the east. Strong downward gradients exist across the Maquoketa and flow across the unit is maximal near the outcrop where total thickness is at a minimum. This strong downward gradient is very recent and is caused by heavy pumpage of the Cambro-Ordovician in urban areas.

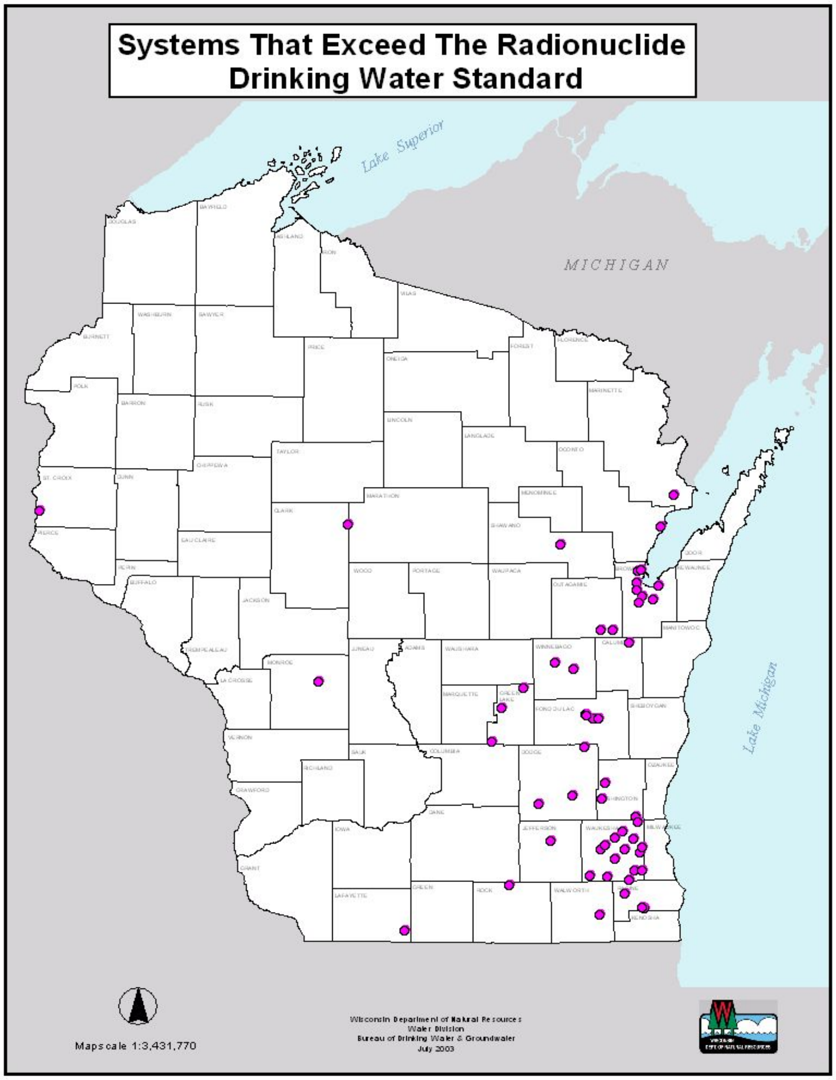

Figure 4.4 Public water systems that exceed 15 pCi/L for gross alpha activity as of July 2003. Source: DNR

The actual cause for high radium and gross alpha activities in the Cambro-Ordovician is undoubtedly a combination of multiple, sometimes subtle, processes that may differ from location to location. Determining which process(es) control the release of solid- phase radioactivity in the Cambro-Ordovician into the groundwater will require a more thorough understanding of the system. Because the source of this radium is not fully understood, basic questions as to how best to manage this increasingly important source of drinking water may be difficult to answer.

Two additional studies were funded by the DNR to address concerns about radioactive compounds in groundwater. In 2000 and 2001, DNR staff collected samples from about 100 community and nontransient noncommunity public water wells. The WSLH analyzed each sample for several alpha-emitting radiochemicals (total Uranium (U-238, U-234, U-235), total Thorium (Th-228, Th-230, Th-232), Radium 226, and Polonium 210) in an attempt to identify and quantify the relative contribution of each chemical to the total gross alpha activity in the samples (Arndt and West, 2004).

Results indicate that radium and its progeny (uranium is a major contributor in relatively few systems, 2 or 3) is the major contributor to high gross alpha activities. Small quantities of polonium and thorium have also been detected but they do not appear to be major contributors to the total gross alpha activity in public water system wells. Another important finding was that total gross alpha measurements are an overestimate of the activities of all of the alpha emitters. The WSLH has developed models to account for the discrepancy between the total gross alpha activity and measurements of individual radionuclides.

In addition, the study showed that the gross alpha activity depends appreciably on the radionuclide used as the calibration standard, the time between sample collection and sample preparation, the time between sample preparation and sample analysis, and whether a radiochemical or a gravimetric method is used to determine the total uranium activity. This is important since according to EPA regulations an adjusted gross alpha activity exceeding 15 pCi/L is considered to be a gross alpha violation. Using the model, it is shown that for some water samples the value obtained for the adjusted gross alpha activity can range from being well within compliance to being well out of compliance. Thus the use of the model developed in this work should be of assistance in helping a water utility with a gross alpha violation determine the reason for the violation, and, therefore, how to correct it.

A second study "Factors Affecting the Determination of Radon in Groundwater" will help determine the impact of expected new EPA standards for radon in drinking water. Staff from the DNR will sample about 340 noncommunity, nontransient and other than municipal water systems per year. To date, approximately 250 samples have been collected from nontransient, noncommunity wells. Preliminary results tend to support findings from earlier community water system monitoring which indicated that approximately 50% of the public water systems monitored in Wisconsin exceed the proposed radon standard of 300 pCi/L. As of July 2006, EPA has not finalized the drinking water standard for radon. – since Wisconsin has a radon air program, the standard will likely be set at 3,000 pCi/L.

References cited:

Arndt, M. F., and L. West. 2004. A Study of the Factors Affecting the Gross Alpha Measurement, and a Radiochemical Analysis of some Groundwater Samples from the State of Wisconsin Exhibiting an Elevated Gross Alpha Activity. Final report submitted to the Wisconsin Department of Natural Resources, DNR Project Number 176.

Grundl, T. 2001. Maquoketa Shale as Radium Source for the Cambro-Ordovician Aquifer in Eastern Wisconsin. Final report submitted to the Wisconsin Department of Natural Resources, DNR Project Number 141.

Summaries of the gross alpha and radon studies are available on the WSLH web site at *http://www.slh.wisc.edu/radiochem/research.html*.

GROUNDWATER QUANTITY

Despite a general abundance of groundwater in Wisconsin, there is a growing concern about the overall availability of good quality groundwater for municipal, industrial, agricultural, and domestic use and for adequate baseflow to our lakes, streams, and wetlands. In a 1997 report titled "Status of Groundwater Quantity in Wisconsin," the GCC concluded that a coordinated effort is needed to determine appropriate management options for addressing groundwater withdrawals, to prioritize information needs, and to implement information and education programs (DNR 1997). The report also called for funding additional data collection and research to address groundwater quantity management issues. Though funding has been scarce some progress on these objectives has been made.

Water Use

As part of the National Water-Use Information Program, the U.S. Geological Survey (USGS) stores water-use data in standardized format for different categories of water use. Information about amounts of water withdrawn, sources of water, how the water was used, and how much water was returned, is available to those involved in establishing water-resource policy and to those managing water resources. In 1978, the USGS entered into a cooperative program with the Wisconsin DNR to inventory water use in Wisconsin. Since that time, five reports have been periodically published summarizing water use in Wisconsin.

Groundwater use statewide grew from 570 to 804 million gallons per day (Mgal/d) from 1985 to 2000 (Ellefson and others, 2002). The majority of groundwater use in 2000 is used for public water supplies (330 Mgal/d), which is primarily for domestic use, but also supplies water for some industrial and commercial purposes. Agriculture and irrigation uses are a close second (295 Mgal/d). The remainder provides water for self-supplied domestic, commercial and industrial uses.

Regional Drawdowns

The effects of groundwater withdrawals are well documented on a regional scale in the Lower Fox River Valley, southeastern Wisconsin, and Dane County. There are substantial declines in groundwater levels in these three areas (**Figure 4.5**). The best-documented regional water quantity problem is in the Southeast part of the State. A recent study by the University of Wisconsin Extension - Wisconsin Geological and Natural History Survey and the U.S. Geological Survey shows that in the last 60 years groundwater withdrawals throughout southeastern Wisconsin, Illinois and Michigan were substantial enough to slow and reverse groundwater flow in some areas (Feinstein and others, 2004). In the region between Milwaukee and Waukesha County, simulations using groundwater models show that pumping water from the deep Sandstone Aquifer has begun to alter groundwater flow patterns extending to Lake Michigan, the Illinois border and western Waukesha County. Indeed, about 7.5 percent of the groundwater that used to flow toward Lake Michigan never reaches the coast; it's drawn into wells. Most of that water eventually reaches Lake Michigan through storm sewers and as treated wastewater, "but the location, timing and quality of the return flow is different than what it was under natural conditions," the USGS report concludes.

Quantity and Quality

An example of how regional drawdown can bring about quality concerns is seen in Southeastern Wisconsin where many communities that use deep wells now have a problem with naturally occurring radionuclides present deeper in the Sandstone Aquifer. Wells in the Sandstone Aquifer have drawn water levels down hundreds of feet and in recent years the concentrations of radionuclides and other elements have increased in many of these wells. There appear to be correlations between large drawdowns and radionuclide concentrations, but the scientific relationships between the two are not yet completely understood. This is a very serious problem as radionuclides are carcinogenic and very costly to remove. Several communities facing a December 2006 deadline for reducing the level of a specific radionuclide, radium, in their drinking water are being forced to look for alternative sources. However, the most available alternative of drilling wells into the shallow aquifer is problematic in that it may impact surface waters or other shallow wells. In addition, shallow wells are more vulnerable than deeper wells to contamination from near-surface sources. Fortunately several communities voluntarily went beyond what state law requires to protect surface waters and other water users in siting their wells and managing their water use.

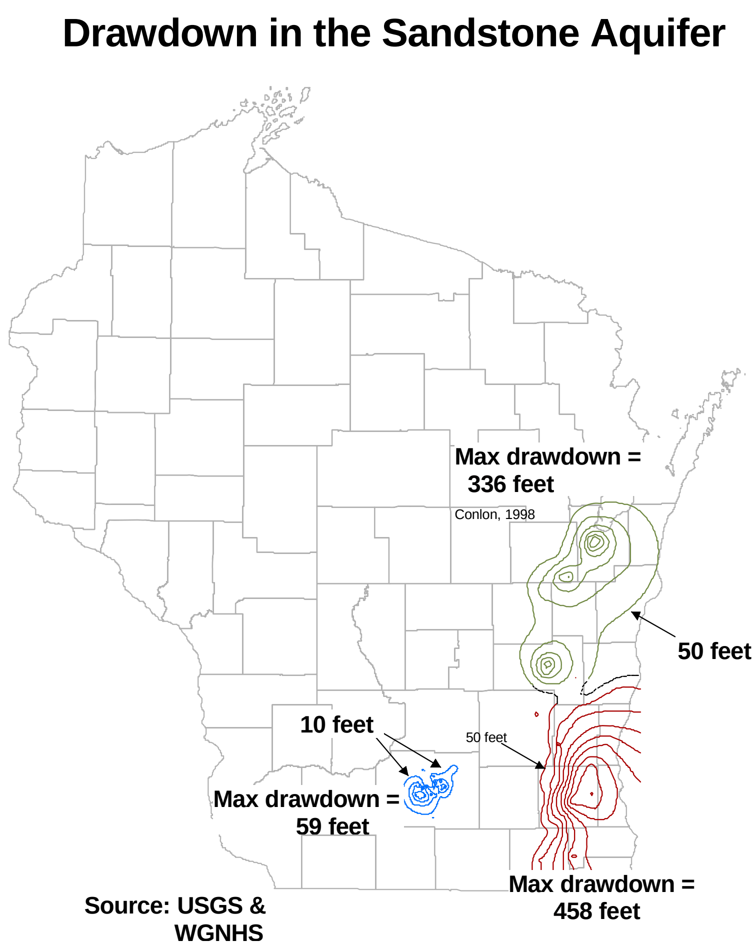

Figure 4.5 Simulated drawdown in the Sandstone Aquifer as of 1998-2000. Contour intervals represent levels of equal hydraulic head and are 50 feet in eastern Wisconsin and 10 feet in Dane County. Sources: USGS and WGNHS

Another example that illustrates the potential that regional drawdown has to cause groundwater quality problems is in the Lower Fox River Valley where detections of arsenic in private well water have increased in recent years (also described above in the Groundwater Quality Section of this Chapter). Investigations in the affected area indicate that most of the arsenic is coming from a highly mineralized zone at the top of the St. Peter Sandstone. It appears that pumping in the Lower Fox River Valley has lowered water levels in the bedrock aquifer to such an extent that the mineralized zone is exposed to the atmosphere and becomes oxidized, releasing arsenic. Some of the arsenic concentrations found in groundwater have been quite high, with 20% of private wells sampled over the new standard of 10 µg/L.

Alternative Sources

Other developments have also highlighted the importance of groundwater quantity. Two communities, Green Bay and Oak Creek, have proposed aquifer storage and recovery (ASR) as a method for addressing water shortages. ASR involves injecting treated water into the aquifer during times of less water use and pumping that water out when water demand is high, typically during the summer. Both communities worked with DNR to conduct pilot studies to determine if this is feasible in Wisconsin. In Green Bay it was determined that ASR, as pilot tested, was not feasible. Significant levels of arsenic and other contaminants were mobilized from aquifer bedrock during the Green Bay pilot test ASR storage periods. In addition, the plan to utilize ASR for water storage at Green Bay changed. Communities surrounding the city that initially considered purchasing drinking water from Green Bay decided to purchase their water from Manitowoc instead. Pilot testing of ASR at Oak Creek has shown that the technology may be viable, although, manganese appears to have been mobilized from aquifer bedrock during the ASR pilot test and levels of this substance in groundwater have increased. Oak Creek has been issued a conditional approval to use ASR, as pilot tested, provided that mobilized substances do not exceed state groundwater quality enforcement standards.

For some communities tapping Lakes Superior and Michigan is a potential solution to quantity problems. But, for other communities, there are bottlenecks. The Council of Great Lakes Governors which consists of Governors from the eight states and premiers from the two Canadian provinces bordering the Great Lakes has taken the lead in protecting the Great Lakes. The Council signed a Great Lakes Charter in 1985 a voluntary agreement setting guidelines and principles for managing Great Lakes water. A key provision of the Charter aimed to regulate large water withdrawals and diversions from metropolitan centers bordering the lakes. The Council also coordinates the authority granted to the Governors under the U.S. Federal Water Resources Development Act (WRDA) of 1986. This Act requires the Governors' unanimous approval on any proposed out-of-basin diversion or export of water from the Great Lakes Basin. To update the regional water management system and ensure that the Great Lakes are protected, the Governors and Premiers signed the Great Lakes Charter Annex in 2001. The Annex includes proposed provisions clarifying how, where and when water can be removed or diverted from the lakes or from groundwater that feeds them. In general it is difficult to receive permission from Great Lakes charter members to divert lake water outside of the basin which extends only some tens of miles from the Lakes in some areas.

On December 13, 2005 the Annex Implementing Agreements were signed by the Great Lakes Governors and Premiers. Once enacted, the signed agreements will provide the necessary framework to help the States and Provinces to protect the Great Lakes Basin. The agreements include a ban on new diversions of water outside the Basin with limited exceptions, were approved. This agreement to manage water quantity in the Great Lakes basin is the first multi-jurisdictional agreement of this magnitude in the world. All 10 governments have agreed to collectively manage water usage according to the shared goals expressed in this agreement. Now the agreement must be approved by the eight state Legislatures and Congress before it can become law.

Surface Water Impacts

Localized effects from groundwater withdrawals are not as well documented as the regional effects. Cases exist around the state where wells, springs, and wetlands have gone dry; lake levels have dropped; and streamflow has been reduced. In 2000, Perrier (Nestle Waters North America) proposed installing one or more wells in the Big Springs area in southeastern Adams County to pump groundwater to be bottled and sold as spring water. Many local residents opposed the Perrier proposal because of concern about potential impacts to the spring. The DNR issued an approval with conditions to protect the aquifer. The proposal highlighted the issue that, for high capacity wells, the DNR only had authority to deny a high capacity well application if it determined that the new well would interfere with a municipal water supply well.

Solutions

The outcome of several years of work on groundwater pumping policy was 2003 Act 310. The authors of the Act touted it as a "good first step", but recognized that further efforts would be needed to adequately manage groundwater resources in Wisconsin. Specifically, the Act:

- Designated "Groundwater Management Areas" (GMAs) in the northeast and southeast where large drawdowns exist in the deep sandstone aquifer. In the GMAs, plans will be written and implemented to help manage groundwater resources in a sustainable manner.

- Regulates new high capacity wells in Groundwater Protection Areas (GPAs) within 1,200 feet of outstanding or exceptional resource waters, or any class I, II, or III trout stream.

- Regulates new wells that may have a significant environmental impact on springs with a flow of at least one cubic foot per second for at least 80% of the time.

- Creates systems for fees and groundwater pumping data management.

- Created a Groundwater Advisory Committee with members appointed by the legislature and governor to provide guidance as to implementing the present law and making recommendations for future legislative efforts.

Gaps exist in Act 310. These include

- No protections from groundwater pumping exist for 99% of lakes, 92% of stream miles, most springs, and all wetlands.

- The 1200 foot buffer provided by GPAs to trout streams and exceptional and outstanding resource waters is not necessarily sufficient to protect these resources from harm.

Still in play is the work of the Groundwater Advisory Committee. Its report to the Legislature may address these and other gaps. The Groundwater Advisory Committee has until the end of 2006 to make recommendations on GMA issues and until the end of 2007 to make recommendations on GPA issues.